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BIOLOGICAL INVESTIGATIONS OF THE DEEP SEA. 46. THE GENUS *LITONOTASTER* (ECHINODERMATA, ASTEROIDEA)[1]

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Two specimens of sea stars were collected by the Institute of Marine Sciences, University of Miami vessels R/V *Gerda* and R/V *Pillsbury* in the Straits of Florida and the Gulf of Guinea. Each represents a new species of the goniasterid genus *Litonotaster*.

These species as well as *L. intermedius*, the type-species, are described. The diagnosis of *Litonotaster* is revised.

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Genus *Litonotaster* Verrill, 1899

Litonotaster Verrill, 1899, pp. 171–172.—Fisher, 1911, pp. 165–166.

Diagnosis: Abactinal plates flat, very thin. All abactinal plates bearing more than a single marginal row, but at least some plates not completely covered by granules. No secondary abactinal plates. Papular areas narrow. Marginal plates flattened. No superambulacral ossicles; no internal radiating ossicles.

Discussion: This genus was erected by Verrill for the single species *Pentagonaster intermedius* Perrier. Verrill (1899: 172) separated it from related genera on the basis of four major characters: "few and minute papular pores and the very limited area on which they occur; the thin and small marginal plates; flexible dorsal surface of the disk; and large number of adambulacral spines." The use of numerous adambulacral furrow spines (seven or eight) as a generic character has since been modified by H. L. Clark (1920: 83–85), who described a species of *Litonotaster* with four or five adambulacral furrow spines. Another important

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character of *Litonotaster* is the abactinal granulation. Verrill (1899: 171) described the abactinal plates as, "finely granulated, with two or more rows of granules around the edges, but with a small, central, round, naked area." Often, not all the plates have a central naked area, and in some specimens most of the plates are completely covered by granules.

The marginal plates of *Litonotaster* are flattened and thin as compared to the angular, massive plates found in most goniasterid genera (see fig. 1). In *Litonotaster intermedius* and *L. tumidus* the superomarginals are mainly in the vertical plane, so that they appear small and inconspicuous (see fig. 1B). This type of marginal plate is also found in other goniasterid genera, e. g. *Pergamaster* and *Tessellaster*. In *L. rotundigranulum*, n. sp. the superomarginals are mainly in the horizontal plane so that they appear large and conspicuous (see fig. 1A). The superomarginals of *L. africanus*, n. sp. are at an angle of about 30° from the horizontal. Thus, the difference between the marginal plates of the type-species, *L. intermedius*, and the marginals of the new species described here are moderate and not of generic importance.

Type-species: Pentagonaster intermedius Perrier (by original designation: Verrill, 1899, p. 171).

Key to the species of *Litonotaster*

1. Actinal plates covered by conical spinules 2
   Actinal plates covered by hemispherical granules ..... *rotundigranulum*
2. Actinal spinules two to three times as high as wide ..... *tumidus*
   Actinal spinules about as high as wide 3
3. Many abactinal plates bearing pedicellariae ..... *africanus*
   No abactinal pedicellariae present ..... *intermedius*

Litonotaster intermedius (Perrier, 1884)
Figures 1B, 2, 3

Pentagonaster intermedius Perrier, 1884, p. 243, pl. 5, figs. 5, 6.
non Pentagonaster intermedius: Alcock, 1893, p. 90.
Litonotaster intermedius: Verrill, 1899, pp. 172–173, pl. 28, figs. 5, 5a, 5b.—H. L. Clark, 1920, p. 85; 1941, pp. 43–44.—Madsen, 1951, p. 88.—A. H. Clark, 1954, p. 375.

Material studied: 28°00′N, 87°42′W, 2685 m, *Albatross* sta. 2379, 2 March 1885, USNM 18443, 1 spec.—26°34′N, 90°31′W, 2379 m, M/V *Oregon* sta. 2571, 27 July 1959, 1 spec.—26°34′N, 89°53′W, 2654 m, M/V *Oregon* sta. 2574, 28 July 1959, 2 spec.

Diagnosis: Abactinal plates covered by small, rounded, closely crowded granules; small central area of some plates bare. No abactinal pedicellariae. Actinal plates covered by short, conical spinules, about as high as wide. Adambulacrals bearing six to eight furrow spines.

Description: Five arms. R = 32 mm; r = 12 mm; R/r = 2.7. General form stellate; disk inflated, dorsal integument thin, flexible; interbrachial arcs rounded.

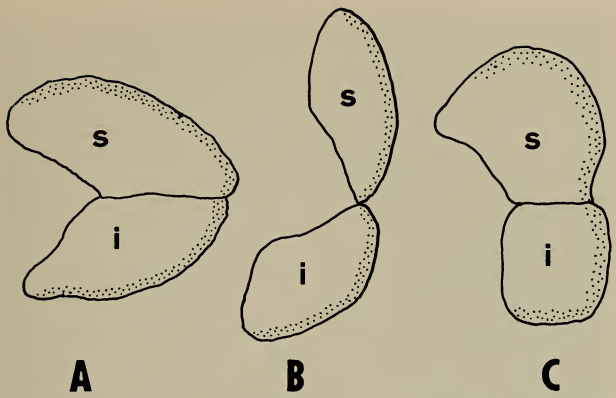

Fig. 1. Lateral view of marginal plates (diagrammatic). Stippling indicates external surface; s, superomarginal plate; i, inferomarginal plate. A, *Litonotaster rotundigranulum*, n. sp.; B, *L. intermedius;* C. *Rosaster alexandri* (illustrating angular marginal plates found in most goniasterid genera.)

Abactinal plates small, flat, irregularly round, closely crowded; covered by small, rounded, closely crowded granules. Small central area of some plates bare. No abactinal pedicellariae. Interradial areas large. Papular areas small, inconspicuous; restricted to narrow bands running from bases of arms to center of disk; no papulae in center of disk. Six papular pores surrounding each plate, each pore containing a single papula.

Twenty marginal plates in each series corresponding throughout. Superomarginals slightly longer than wide; one or two pairs in contact medially. Each plate surrounded by row of granules similar to those on abactinals. Superomarginals in interbrachial arc having lower two-thirds covered by coarse, rounded granules, about twice as large as peripheral granules; upper third naked or with several scattered granules. Naked area becoming larger distally, so that last three or four plates bearing only peripheral row of granules. In interbrachial arcs lateral angle of each plate depressed; plates flattened, mainly in vertical plane (see fig. 1B). Plates becoming more angular distally. Inferomarginal plates square in interbrachial arc, becoming longer than wide distally; covered by short, conical spinules. Some plates bearing two or three valved, short, excavate pedicellariae; valves as high as wide. Terminal plate heart-shaped; distal end notched, proximal end truncate.

Actinal intermediate area large; actinals not extending down arm. Actinal plates flat, polygonal; completely covered by short, conical spinules, about as high as wide. Some plates bearing short, excavate pedicellariae similar to those on inferomarginals.

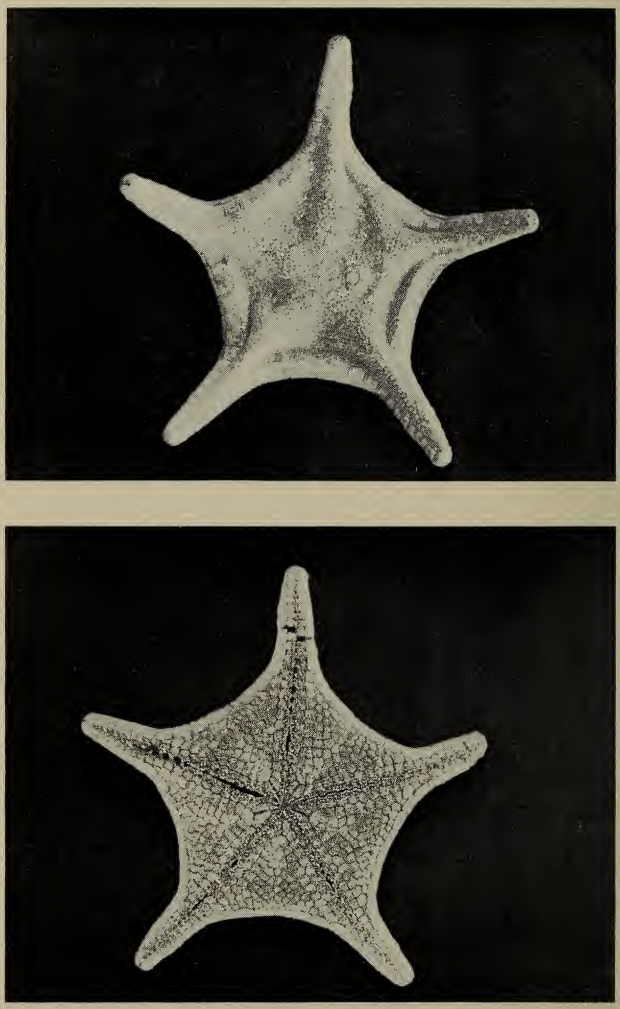

FIG. 2. *Litonotaster intermedius* (Perrier), from *Oregon* sta. 2574. Top, abactinal view; 1.1×. Bottom, actinal view, 1.1×.

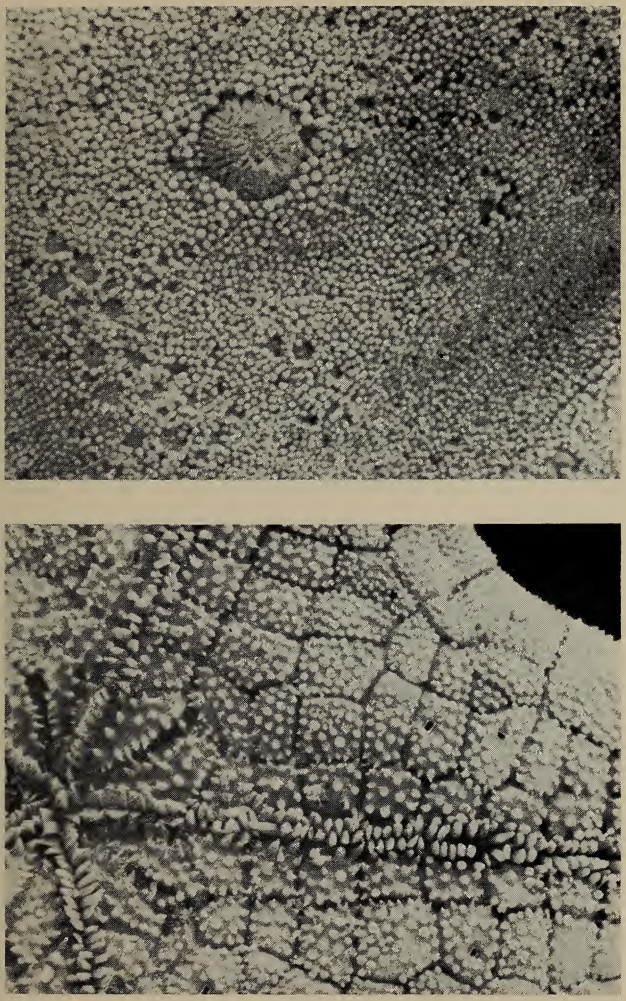

FIG. 3. *Litonotaster intermedius* (Perrier), from *Oregon* sta. 2574. Top, abactinal view; 8.3×. Bottom, actinal view; 7.9×.

Adambulacral plates large, rectangular (slightly wider than long), corresponding with adjacent actinals. Furrow margin straight, bearing six to eight short, blunt, compressed, subequal furrow spines. Three to four irregular rows of subambulacral spines, similar to those of actinals, covering rest of plate. Most plates bearing two or three valved excavate pedicellariae, ranging from as high as wide to almost three times as high as wide.

Mouth plates large with long furrow margins. Each plate bearing twelve or thirteen furrow spines; first nine or ten similar to adambulacral furrow spines; next two slightly taller and more strongly compressed. Median spine about one and one-half times taller than other spines, very strongly compressed. Rest of plate covered by two to three irregular rows of spinules parallel to suture; spinules similar to those of actinals. Suture broad, prominent.

Madreporite irregularly round, about twice as large as adjacent abactinals.

Type: The type was originally deposited in the Museum of Comparative Zoology, Harvard Univ., but is no longer in their collection. It is presumed lost.

Type-locality: 24°33′N,84°23′W, 3532 m, *Blake* sta. 31.

Distribution: This species is known from the Gulf of Mexico (2379–3532 m) and from the Windward Passage between Cuba and Hispaniola (1958–3294 m).

Discussion: The granulation of the abactinal plates is variable. In one specimen most of the plates are completely covered by granules. In another specimen, most of the plates have a very small, central naked area, bearing one to three scattered granules. In a third specimen, all the plates are surrounded by two or three rows of granules. The central areas are wide and completely naked.

The superomarginals are usually in the vertical plane, but can be close to the horizontal plane or at any angle between.

Litonotaster africanus new species
Figures 4, 5

Material studied: Holotype: R = 43 mm, r = 21 mm, R/r = 2; 01°09′-N, 07°45′E, 2525 m, R/V *Pillsbury* sta. 266, 17 May 1965, USNM E10863.

Diagnosis: Abactinal plates covered by rounded, coarse, closely crowded granules. Small central area of some plates bare. Many plates bearing one or two moderately large, two or three valved excavate sugar-tong pedicellariae. Actinals covered by short, conical spinules, about as high as wide. Adambulacral plates bearing six to seven furrow spines.

Description: Five arms. R = 43 mm; r = 21 mm; R/r = 2.

General form stellate; arms strongly tapered; disk inflated; dorsal integument thin, flexible; interbrachial arcs rounded.

Abactinal plates small, flat, irregularly round, closely crowded; covered

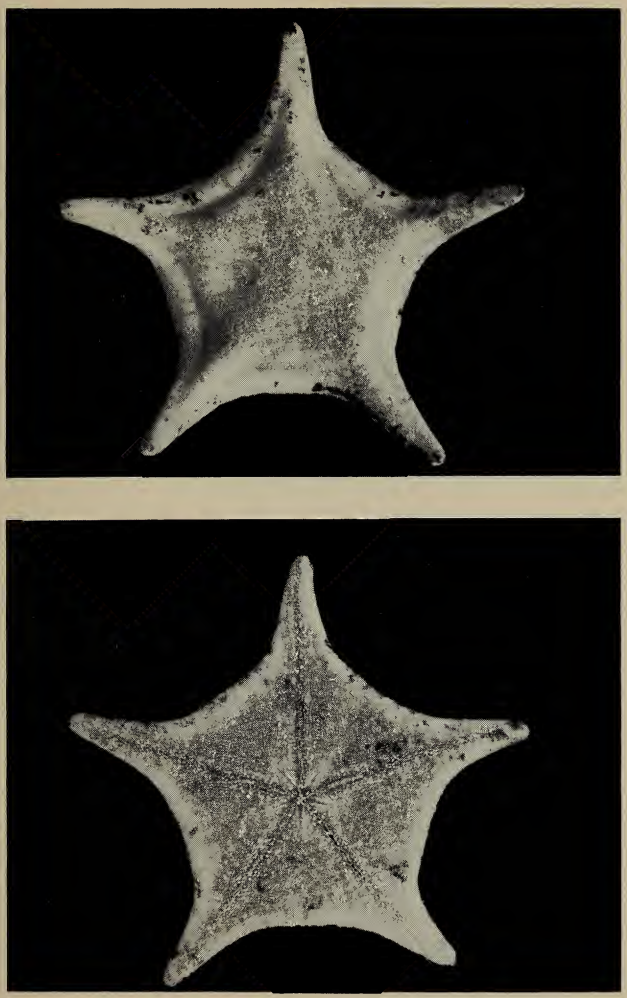

FIG. 4. *Litonotaster africanus*, n. sp., holotype. Top, abactinal view; 0.9×. Bottom, actinal view, 0.9×.

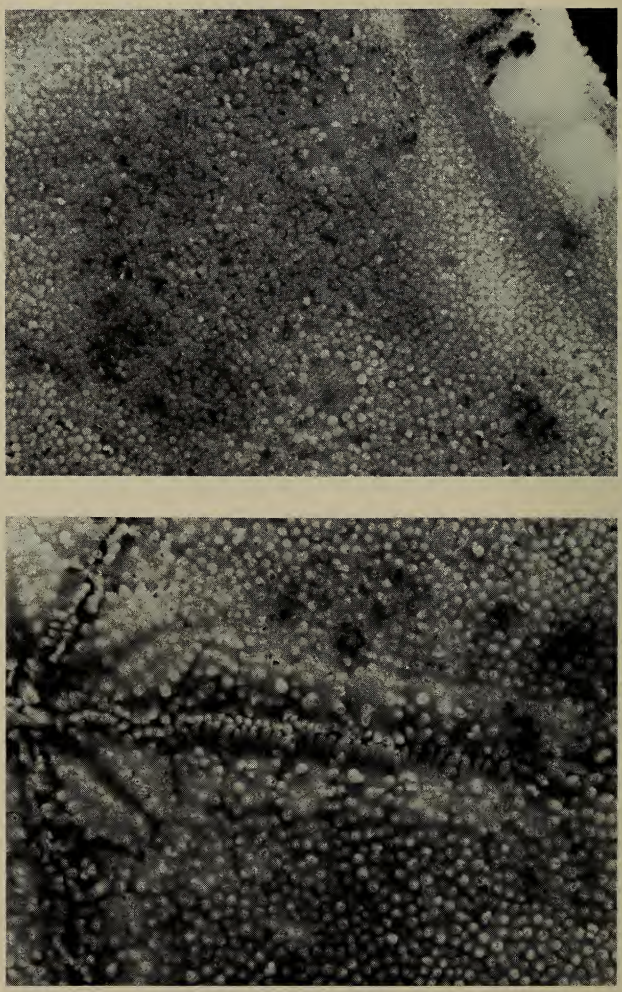

FIG. 5. *Litonotaster africanus,* n. sp., holotype. Top, abactinal view; 5.1×. Bottom, actinal view, 6.1×.

by rounded, coarse, closely crowded granules. Small central area of some plates bare. Many plates bearing one or two moderately large, two or three valved excavate sugar-tong pedicellariae. Interradial areas large. Papular areas small, inconspicuous; restricted to narrow bands running from bases of arms to center of disk; no papulae in center of disk. Six papular pores surrounding each plate, each pore containing a single papula.

Twenty-two plates in each marginal series corresponding proximally, but tending to alternate distally. In interbrachial arcs lateral angle of each plate depressed; plates flattened. Plates becoming more angular distally. Superomarginal plates at an angle of about 30° from the horizontal. Superomarginals square; three or four pairs in contact medially. Each plate surrounded by one row of granules on three sides; two to four irregular rows on side adjacent to inferomarginals. Marginal granules rounded, similar to those on abactinals. Center of plates naked, except for scattered granules and excavate sugar-tong pedicellariae similar to those of abactinals. Inferomarginal plates square or pentagonal; covered by very short, conical spinules. Some plates bearing pedicellariae similar to those of abactinals. Terminal plate roundly triangular; distal end surmounted by short, blunt tubercle.

Actinal intermediate area large; single row of actinals extending about half way down arm. Actinal plates small, flat, polygonal; completely covered by short, conical spinules, about as high as wide. Many plates bearing two or three valved pedicellariae similar to those found on abactinals.

Adambulacral plates large, rectangular (slightly wider than long), corresponding with adjacent actinals. Furrow margin straight, bearing six or seven short, blunt, compressed, subequal furrow spines. Three to four irregular rows of subambulacral spines similar to those of actinals covering rest of plate. Most plates bearing two or three valved excavate sugar-tong pedicellariae, similar to but slightly larger than those found on other plates.

Mouth plates large with long furrow margin. Each plate bearing thirteen furrow spines; first ten similar to adambulacral furrow spines; next two slightly taller and more strongly compressed. Median spine about one and one-half times taller than other spines, very strongly compressed. Rest of plate covered by two to three irregular rows of spinules parallel to suture; spinules similar to those of actinals. Suture broad, prominent.

Madreporite round, about three times as large as adjacent abactinals.

Type: United States National Museum, cat. no. E10863.

Type-locality: Gulf of Guinea, off São Tomé, 01°09′N, 07°45′E, 2525 m, R/V *Pillsbury* sta. 266.

Distribution: This species is known only from the type-locality.

Discussion: Only a small number of the abactinal plates have a central, naked area, but no fewer than in some specimens of *Litonotaster intermedius*, the type-species.

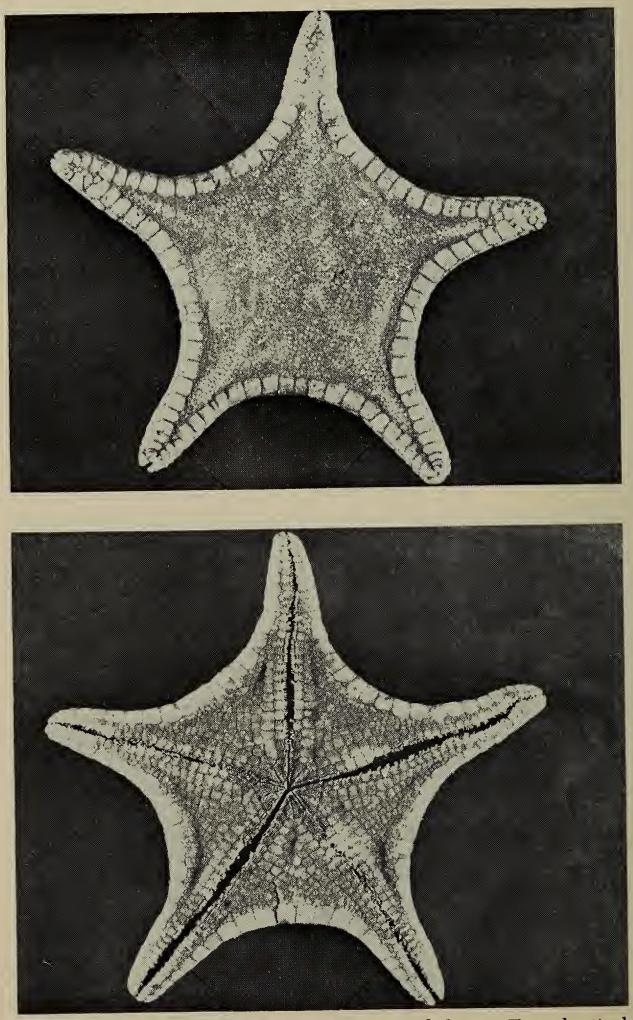

FIG. 6. *Litonotaster rotundigranulum,* n. sp., holotype. Top, abactinal view; 0.7×. Bottom, actinal view; 0.7×.

This species is closely related to *L. intermedius.* It is distinguished from it by the coarse granules and the pedicellariae on the abactinal plates. Also, the holotype is considerably larger (R = 43 mm) than the largest specimen of *L. intermedius* known (R = 27 mm).

Litonotaster tumidus H. L. Clark, 1920
Figure 8

Litonotaster tumidus H. L. Clark, 1920. pp. 83–85, pl. 3, figs. 3–6.—Madsen, 1951, p. 88.

Material studied: Paratype: Peru, SW of Palominos Light House, 88 miles, 5196 m, *Albatross* sta. 4672, MCZ 2717.

Diagnosis: No abactinal pedicellariae. Actinal and inferomarginal plates covered by long spinules two to three times as high as wide. Adambulacral plates bearing four or five furrow spines.

Type: The holotype is apparently lost. The extant paratypes are in the United States National Museum (cat. no. E705) and the Museum of Comparative Zoology (cat. nos. 2675 and 2717).

Type-locality: Peru, SW of Palominos Light House, 88 miles, 5196 m, *Albatross* sta. 4672.

Distribution: This species is known from off the coast of Peru, 4066–5196 m.

Discussion: Litonotaster tumidus is closely related to *L. intermedius.* It is distinguished from it by its tall actinal and inferomarginal spinules and the small number of adambulacral furrow spines (four or five).

Litonotaster rotundigranulum new species
Figures 6, 7

Material studied: Holotype: R = 60 mm, r = 29 mm, R/r = 2; 23°54′N, 82°19′W, 1135–1184 m, R/V *Gerda* sta. G–448, 1 December 1964, USNM E10862.

Diagnosis: Disk large. Superomarginal plates prominent. Actinals covered by large, hemispherical granules. Seven or eight furrow spines in proximal half of ambulacral furrow, five or six distally. No pedicellariae.

Description: Five arms. R = 60 mm; r = 29 mm; R/r = 2.

General form stellate with large disk; arms tapering regularly to a bluntly pointed tip; disk slightly inflated; dorsal integument very thin, flexible; interbrachial arcs broadly curved.

Small, flat, very thin abactinal plates irregularly round, closely crowded; covered by small, rounded granules. Small central area of most plates bare; some with one to four scattered granules. No secondary plates.

Interradial areas large. Papular areas small, inconspicuous; restricted to narrow bands running from bases of arms to center of disk; no papulae in center of disk. Six papular pores surrounding each plate, each pore containing a single papula.

Twenty-four to twenty-eight large superomarginal plates corresponding with inferomarginals in interbrachial arc, but irregular in shape,

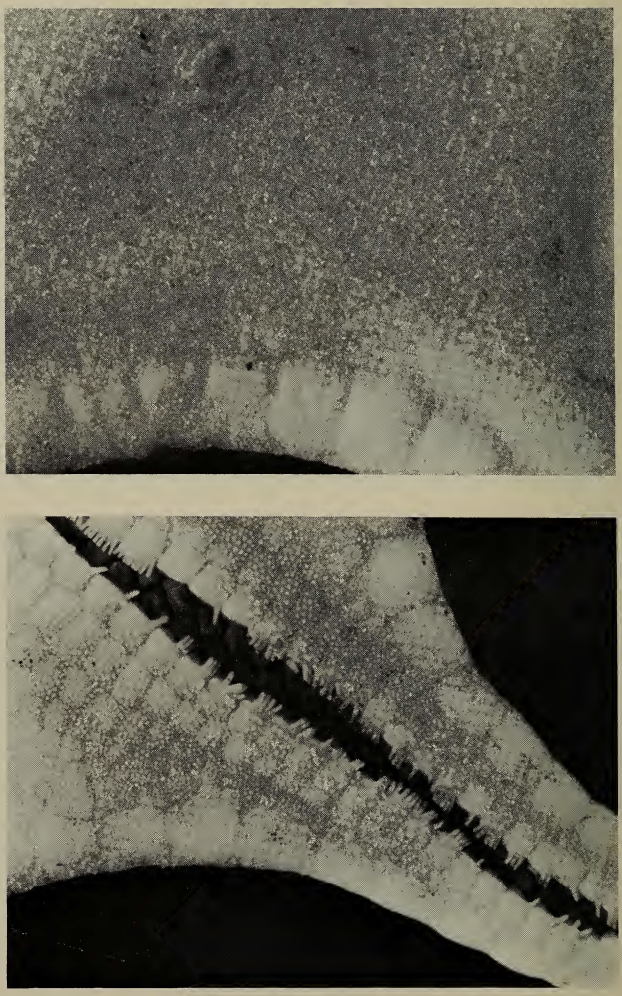

FIG. 7. *Litonotaster rotundigranulum,* n. sp., holotype. Top, abactinal view; 3.2×. Bottom, actinal view; 3.0×.

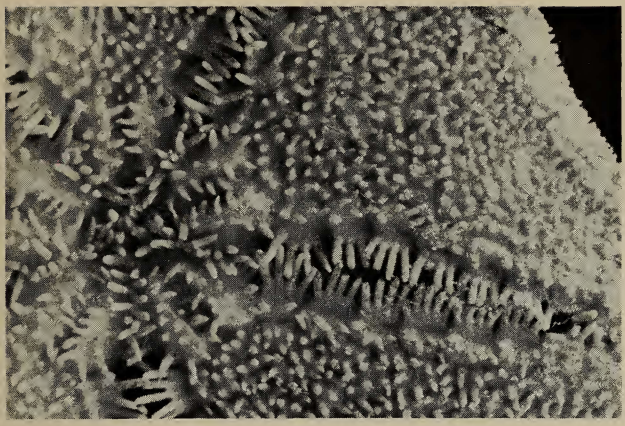

FIG. 8. *Litonotaster tumidus* H. L. Clark, from *Albatross* sta. 4672, actinal view; 9.0×.

number and correspondence in distal parts of arms; plates square in interbrachial arc, becoming wider than long distally; one to four pairs in contact medially. Lower half of each plate completely covered by large, hemispherical granules. Upper half bordered by a row of granules; center bare or with scattered granules. Lateral angle of superomarginals depressed so that each plate is flattened, moderately thin; becoming more angular distally. Superomarginals mainly in horizontal plane. Terminal plate moderately large, naked, swollen, heart-shaped; distal end notched, proximal end truncate. Twenty-six to thirty inferomarginal plates; always two more than in superomarginal series. Inferomarginals completely covered by large, hemispherical granules similar to those of superomarginals.

Actinal intermediate area large. Plates large, rhombic except near marginals, where small, irregular. Actinals flat, well defined; completely covered by large, hemispherical granules.

Adambulacral plates square or sometimes pentagonal, corresponding with adjacent actinals, which are twice as wide; furrow margin straight. Six or seven furrow spines in proximal half of ambulacral furrow, five or six distally; spines short, blunt, compressed, subequal. First row of actinal series of five or six very short, blunt spines; rest of actinal series consisting of three irregular rows of five or six large, hemispherical granules like those of actinals.

Mouth plates very large, with long furrow margin. Each plate with ten short, blunt furrow spines; first nine spines subequal, like adambulacral

furrow spines; median spine only slightly larger. Rest of plate covered by large hemispherical granules like those of actinals except for short, blunt spines at suture; suture broad, prominent.

Madreporite deeply furrowed, rhombic, about four times larger than surrounding plates; one-third the distance from center of disk to middle of interbrachial arc.

No pedicellariae.

Type: United States National Museum, cat. no. E10862.

Type-locality: Straits of Florida, on Pourtales Plateau, S. of Key West; 23°54′N, 82°19′W, 1135–1184 m, R/V *Gerda* sta. G–448.

Distribution: This species is known only from the type-locality.

Discussion: This species is not closely related to the other known species of *Litonotaster*. It differs in its general body form, actinal granulation and lack of adambulacral pedicellariae. These differences are not sufficient to erect a new genus and *Litonotaster* can be expanded to accommodate this new species.

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